Plethysmography – Upper and Lower Extremities

CHAPTER 9

Capabilities

- Aids in combination with segmental pressures in documenting the presence, level and severity of arterial disease
- Helps in differentiating between true vascular and nonvascular symptoms
- Allows for a method of follow up testing for the progression of the disease, and any surgical or interventional procedures

Limitations

- Determines volume changes; it is unable to give specific information about a single vessel
- Unable to differentiate between collateral flow and primary arterial flow
- Room temperature and medications can affect the waveform
- Open wounds may inhibit sensor placement
- Obesity may inhibit accurate readings
- Digits with low pressure of <20 mmHg may not create a waveform

Technical Error

- Photoplethysmography sensors may not adhere well to skin
- Caffeine, nicotine, and medication may affect waveforms
- Patient movement (involuntary or voluntary) will affect waveforms

Air-Filled Plethysmography

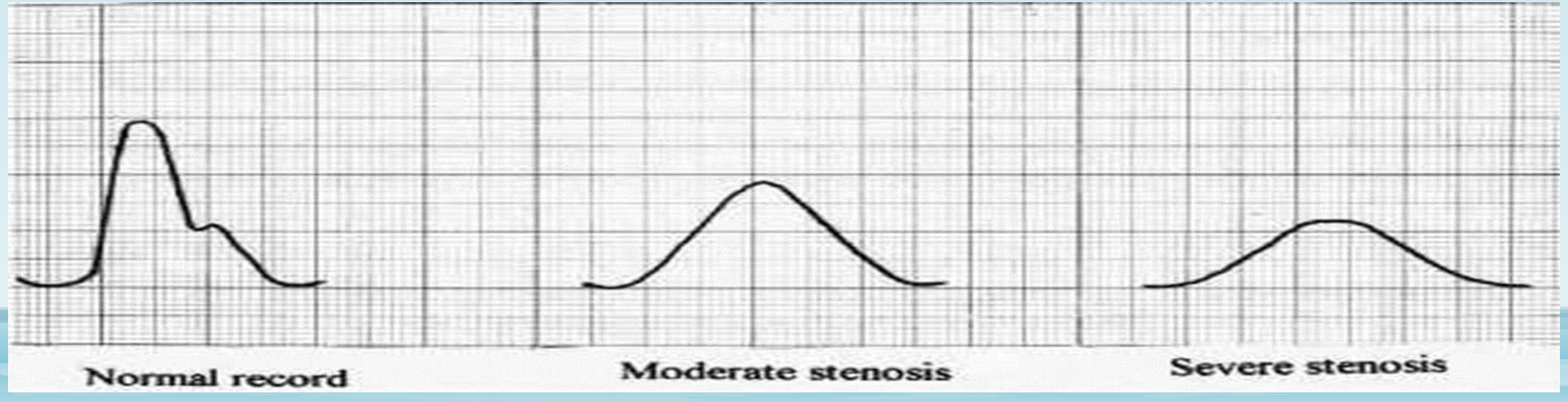
- Also called ***Pulse Volume Recording*** (PVR) or ***Volume Plethysmography***
- Patient is supine
- Pneumatic cuffs are placed on the limbs (just as for segmental pressures)
- Cuff is inflated to a low pressure (~60-65 mmHg)

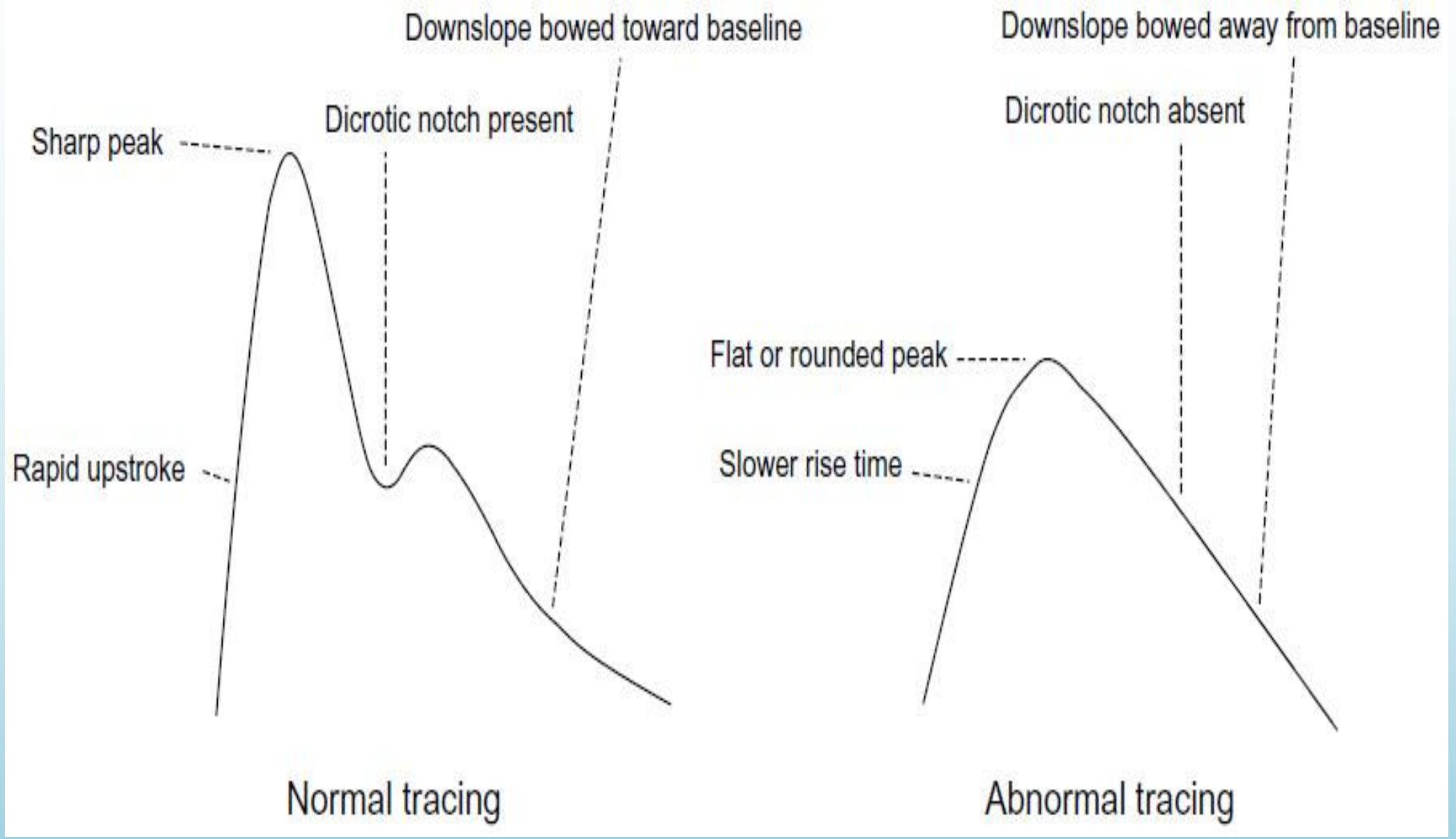
Air-Filled Plethysmography

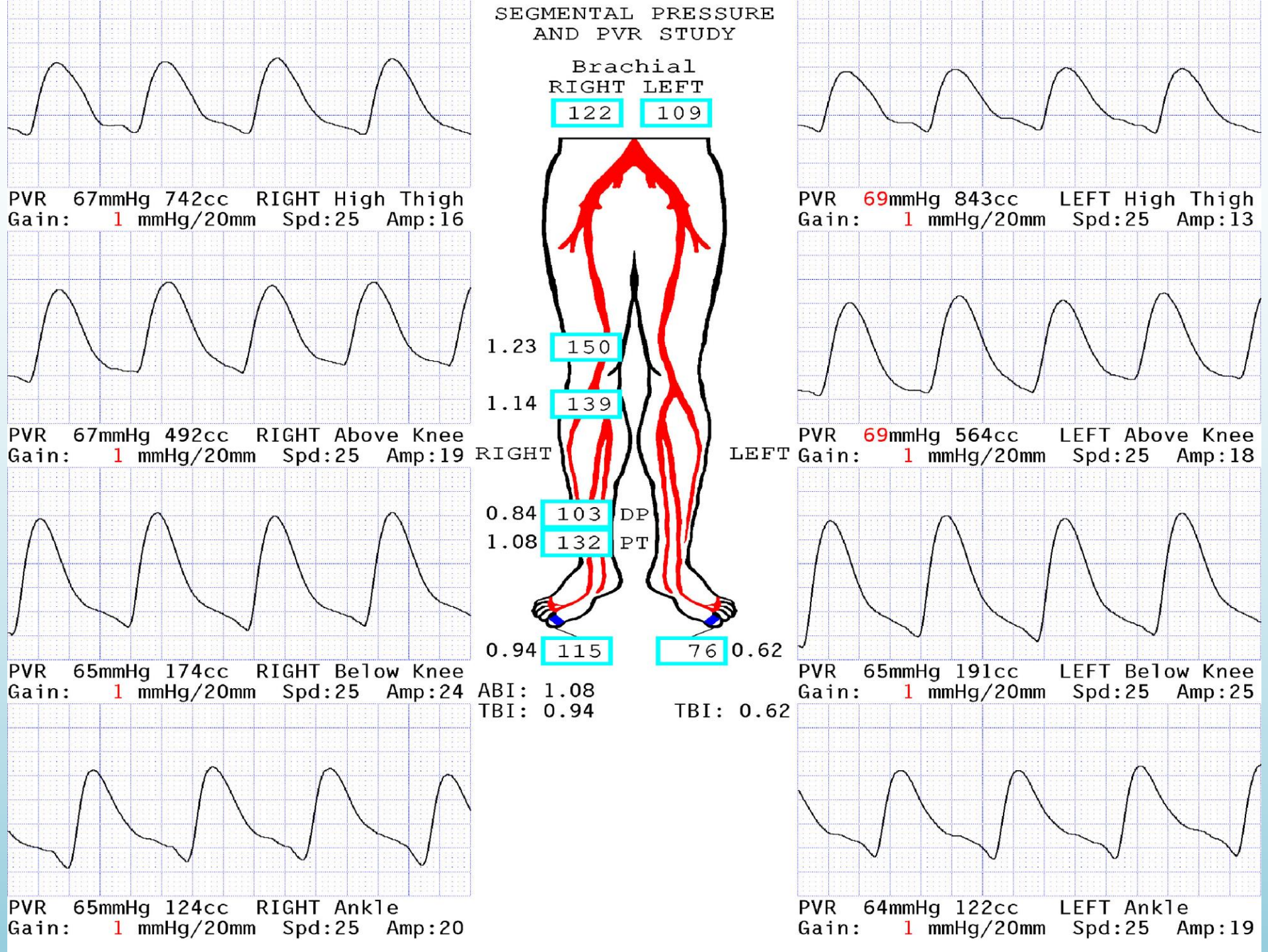
- Volume changes in the limb create a pressure change which is converted to an analog recording
  - Volume changes are a result of arterial blood flow moving through the arteries, arterioles, capillaries etc.
    - The more arterial flow that is present; the larger the waveform (normal)
    - The lesser arterial flow that is present; the smaller the waveform (abnormal)

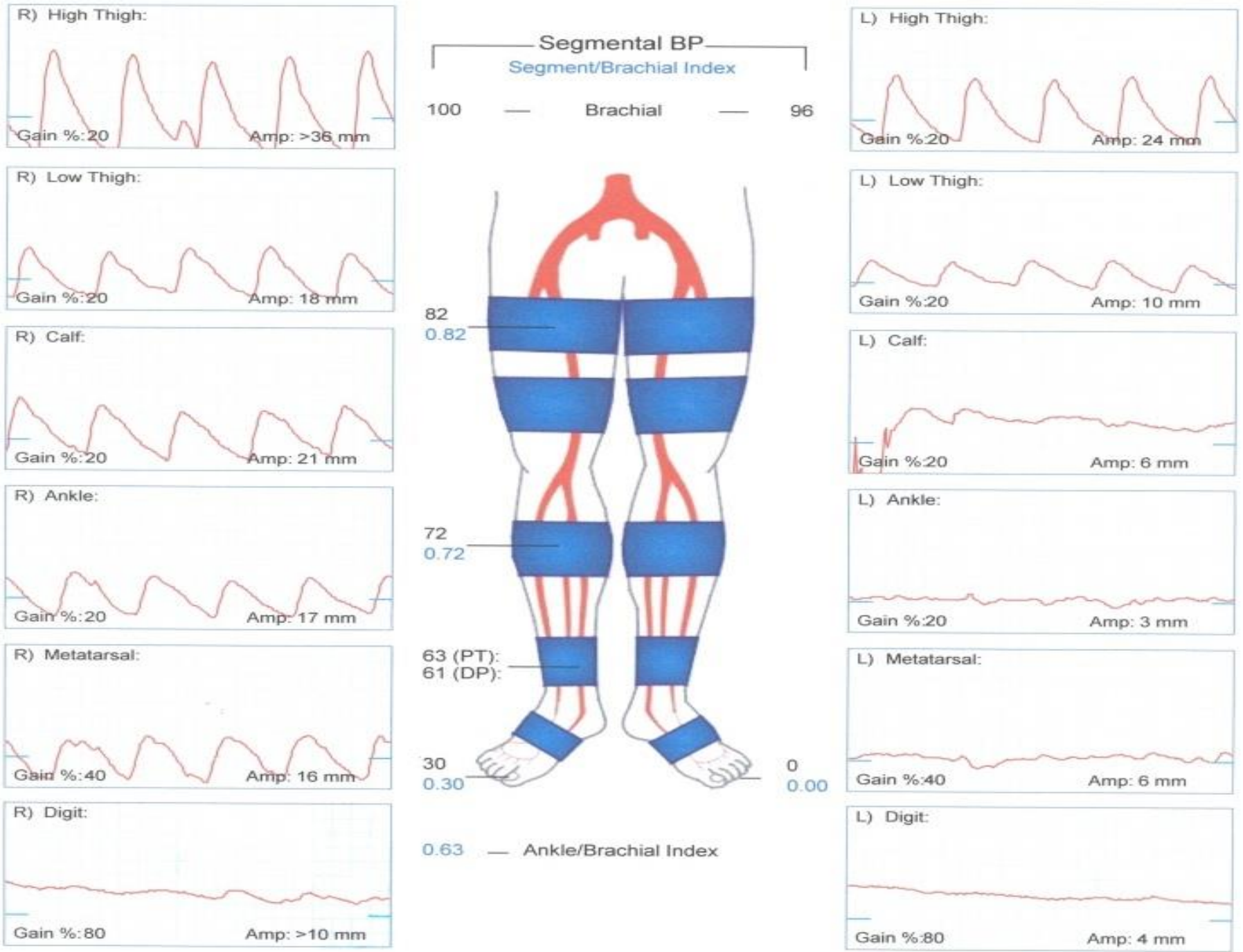
Air-Filled Plethsymography

- Moderate or severely abnormal waveforms are significant for disease proximal to the level of the tracing
- Plethysmography alone can underestimate the significant of the obstruction




Downslope bowed toward baseline
Dicrotic notch present
Sharp peak
Rapid upstroke
Normal tracing
Downslope bowed away from baseline
Dicrotic notch absent
Flat or rounded peak
Slower rise time
Abnormal tracing


SEGMENTAL PRESSURE
AND PVR STUDY
Brachial
RIGHT LEFT
122 109
PVR 67mmHg 742cc RIGHT High Thigh
Gain: 1 mmHg/20mm Spd:25 Amp:16
PVR 69mmHg 843cc LEFT High Thigh
Gain: 1 mmHg/20mm Spd:25 Amp:13
1.23 150
1.14 139
PVR 67mmHg 492cc RIGHT Above Knee
Gain: 1 mmHg/20mm Spd:25 Amp:19
PVR 69mmHg 564cc LEFT Above Knee
Gain: 1 mmHg/20mm Spd:25 Amp:18
RIGHT
LEFT
0.84 103 DP
1.08 132 PT
PVR 65mmHg 174cc RIGHT Below Knee
Gain: 1 mmHg/20mm Spd:25 Amp:24
PVR 65mmHg 191cc LEFT Below Knee
Gain: 1 mmHg/20mm Spd:25 Amp:25
0.94 115
76 0.62
ABI: 1.08
TBI: 0.94
TBI: 0.62
PVR 65mmHg 124cc RIGHT Ankle
Gain: 1 mmHg/20mm Spd:25 Amp:20
PVR 64mmHg 122cc LEFT Ankle
Gain: 1 mmHg/20mm Spd:25 Amp:19


R) High Thigh:
Gain %:20
Amp: >36 mm
R) Low Thigh:
Gain %:20
Amp: 18 mm
R) Calf:
Gain %:20
Amp: 21 mm
R) Ankle:
Gain %:20
Amp: 17 mm
R) Metatarsal:
Gain %:40
Amp: 16 mm
R) Digit:
Gain %:80
Amp: >10 mm
Segmental BP
Segment/Brachial Index
100
Brachial
96
82
0.82
72
0.72
63 (PT):
61 (DP):
30
0.30
0
0.00
0.63
Ankle/Brachial Index
L) High Thigh:
Gain %:20
Amp: 24 mm
L) Low Thigh:
Gain %:20
Amp: 10 mm
L) Calf:
Gain %:20
Amp: 6 mm
L) Ankle:
Gain %:20
Amp: 3 mm
L) Metatarsal:
Gain %:40
Amp: 6 mm
L) Digit:
Gain %:80
Amp: 4 mm

Photoplethysmography

- Also called “PPG”
- Consists of transducer, amplifier, and strip-chart recorder
- Detects cutaneous blood flow and records pulsations
  - Rapid changes of blood flow in the skin are recorded as pulsatile waveforms that align with the heartbeat

Photoplethysmography

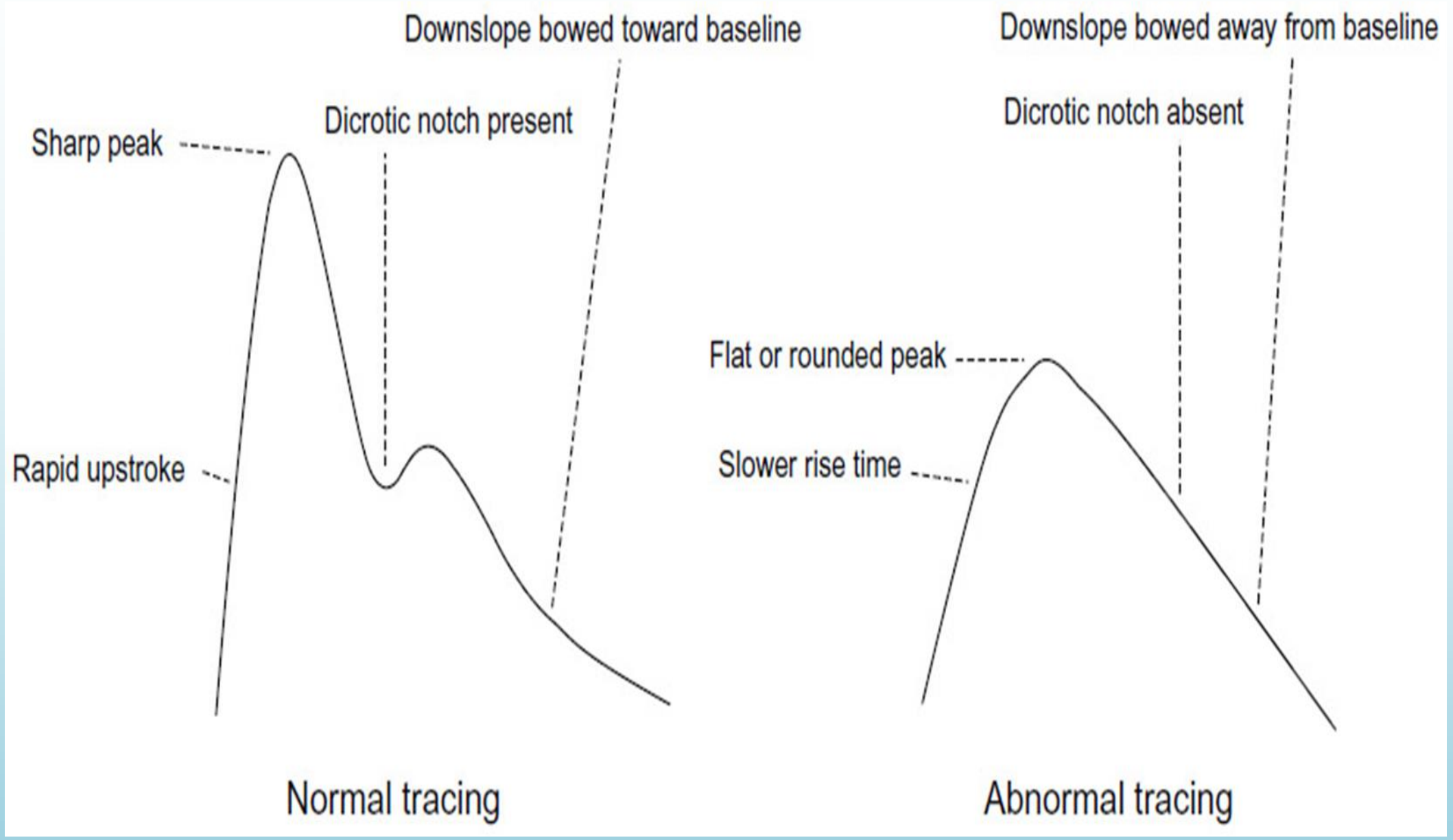
- Infrared light is transmitted into the superficial tissues and a portion of the signal is reflected back to the photo-sensor
  - Small PPG sensor is attached to the skin with double stick tape or Velcro strips
- Waveform represents the arterial inflow and the venous outflow of the capillary system
- Waveform cannot quantitate flow but it can be qualitative

PPG Interpretation

- 1. Normal Pulse Contour
  - Steep systolic upslope
  - Narrow systolic peak
  - Dicrotic notch on the down-slope
- 2. Mildly Obstructive Contour
  - Loss of dicrotic notch
  - Slight bowing of the down-slop away from the baseline

PPG Interpretation

- 3. Moderately Obstructive Contour
  - Same changes seen in mild with the addition of a delay in the upstroke and appearance of a rounded peak
- 4. Severe Obstruction Contour
  - Low amplitude
  - Broadening of the contour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Displacement Plethysmography

- Displacement Plethysmography is no longer used, however it was the founding basis for current plethysmography practices
- Consists of a water-filled tank where a body part is immersed
- As the volume of the immersed body part increases, the water displacement is proportional
  - Spirometer is activated and a tracing of the water volume change is made